UNITED NATIONS E

ECONOMIC AND SOCIAL COUNCIL

Distr.
LIMITED
E/ESCWA/SDPD/2005/WG.1/9
14 April 2005
ORIGINAL: ENGLISH

ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA

Workshop on "Training of Trainers on the Application of IWRM Guidelines in the Arab Region"
Kuwait, 14-18 May 2005

MODULE EIGHT

BALANCING WATER SUPPLY AND DEMAND

Note: This document has been reproduced in the form in which it was received, without formal editing.

05-0234

MODULE 8 BALANCING WATER SUPPLY AND DEMAND	
RATIONAL	The module will assist water managers and engineers to formulate a water resources management framework and initiate actions (that are environmentally, socially, politically, economically sustainable) to balance water supply and demand. The module suggests a paradigm for a comprehensive management framework for large-scale water management problems in ESCWA countries that suffer from supply demand gap. This management framework can help to achieve sustainable water resources for meeting water demand and preventing the gridlock and excessive legal expense of uncoordinated and conflict-filled decision processes. This module is presented to identify attributes of the paradigm and explain how it can be applied. Physical interactions of the ground and surface water systems, environment, politics, economics, and sociological requirements will be integrated and quantified using IWRM principals and dimensions into the management framework to balance water supply and demand.
OBJECTIVES	1. Discuss water related problems in the ESCWA region. 2. Discuss the available options for closing the supply-demand gap in ESCWA countries. 3. Describe planning criteria within the IWRM principals. 4. Develop a decision process to select suitable options to meet supply-demand gap. 5. Demonstrate the approach of balancing supply and demand through case studies and applied exercises.
MAIN REFERENCES AND BACKGROUND MATERIAL	- CDM (1997) *Comprehensive Planning Framework for Palestinian Water Resources Development: Task 4*. Rammallah - ESCWA. (1999). *Current water policies and practices in selected ESCWA member countries*, E/ESCWA/ENR/1999/15. - ESCWA. (1999). *Updating the assessment of water resources in ESCWA member countries*, E/ESCWA/ENR/1999/13.
SUGGESTED INTERNET LINKS	
DELIVERY OPTIONS	
DIRECTLY RELATED MODULES	4, 6, 10, 13

SESSION TOPIC SYNTHESIS	
QUESTIONS FOR DISCUSSION	1. General approach for closing supply and demand in ESCWA countries. 2. Options for closing the supply-demand gap in ESCWA countries. 3. Description of planning criteria within IWRM principals. 4. Screening and comparative evaluation procedures. 5. Development of scenarios from retained option. 6. Exercise.

General approach for balancing water supply and demand in ESCWA Countries

By all measures, the ESCWA region is considered one of the most water-stressed areas in the world, and its long-term water situation is becoming increasingly uncertain. Water balances either have already slumped into serious deficit in some countries or are moving steadily in this direction. ESCWA member countries are left with one option: to manage their water resources efficiently in order to reduce the gap between supply and demand and ensure sustainability of water resources. Water is a unitary resource that should be managed based on the IWRM principals and dimensions to reflect the needs of all social, economic, environmental and public health targets of the country. The module will assist water managers and engineers to formulate a water resources management framework and initiate actions (that are environmentally, socially, politically, economically sustainable) to improve and manage the water sector. For this end, a number of essential steps towards balancing supply and demand should be taken into consideration, which include the following:

1. Definition of targeted objectives in closing the supply-demand gap, assessment of available water resources and analysis of water demand based on a number of scenarios,
2. Development and definition of options for solution considering:
   a. Environmental, economical, social, and legal aspects,
   b. Institutional consideration and public participation,
3. Generation of options,
4. Choice of optimal option.

Options for closing the supply demand gap in ESCWA countries

The options for closing the gap between supply and demand should consider various means of matching supply and demand, and of satisfying environmental concerns. The module summarizes the various strategic options that either have been adopted in some ESCWA countries or are in the process of adoption.

Description of planning criteria

In developing and analyzing various policy options, the water resources manager must strike a balance between the ideal and the practical forms of water resources management for a country. The manager should in any event avoid producing a list of options and recommendations that is a "wish-list", divorced from practical considerations of the resources available to implement a water resources strategy. Options for reducing the gap between supply and demand differ in the amount and timing of the capital investment required, in the amount of operating and maintenance cost, in useful life of the capital investment, in effectiveness, and in their economic and environmental impact on the area. The assessment criteria used to rank the different potential options to meet the future national and regional water demand in terms of quantity and quality includes different aspects. These are technical aspects, financial aspects, environmental impacts, social implications, institutional aspects, and political implications.

Planning criteria will serve as a tool and set the framework for decision- making regarding the development and selection of different options. Planning criteria for water resources management should be well integrated into the context of 5 years socio-economic development plans and be recognized as one of the main national development priorities in terms of addressing the issue of water scarcity and imbalance between water supply and demand within the IWRM framework. This is also in line with the United Nations Millennium Declaration Goals (No.7) and Johannesburg Plan of Action to develop IWRM and water efficiency plans by 2005.

The criteria can be classified into the following categories:

(a) *Financial viability*: unit cost of water, dollars per cubic meter, affordability an prospects for fund generation
(b) *Technical viability*: availability of technology, implementability, flexibility and reliability of technology, feasibility and knowledge of Water resources
(c) *Source viability*: availability and hydrologic certainty of the source, sustainability of quantity and quality and flexibility of supply development
(d) *Political viability*: willingness of beneficiaries to incur higher costs for improved services; participate in various stages of water resources planning, political stability and cooperation among riparians, compliance with international laws and existing agreements.
(e) *Institutional viability*: availability, capacity and mandate of institutions to plan, manage, implement and enforce decisions
(f) *Environmental viability*: impacts on the built environment and on the physical and natural environment
(g) *Social viability*: public participation and fulfillment of development needs

Screening and comparative evaluation procedures

Multi-criterion Decision Making (MCDM) techniques can be applied to evaluate and choose optimal and applicable water resources management options to a selected area. The most appropriate technique for application to the type of problem typified by watershed resources management is the rating technique, which is based on the "direct weighing" approach by a focus group. This approach allows water managers to select the options that are considered more compatible with the planning criteria. The most favorable options can be combined or assembled in different ways to form individual and distinct scenarios for the development and management of water resources. The module includes an exercise, which will guide participants on how the management framework can be applied to balance water supply and demand to a selected area based on IWRM principals and dimensions.

TABLE OF CONTENT

LIST OF BOXES, FIGURES AND TABLES

MODULE 8
BALANCING WATER SUPPLY DEMAND

A. WATER RELATED PROBLEMS IN THE ESCWA REGION

Despite serious efforts to deal with water scarcity and mismanagement of the resource over the last 25 years, most ESCWA member countries still face serious water problems owing to increased population growth and urbanization, enhanced socio-economic development activities in the region and the growing and competing demand for water among different types of users. The availability of conventional water resources has been affected by the depletion of water supplies and the deterioration of water quality. Whereas the options for developing non-conventional water resources has been hindered by financial constraints. Water scarcity, increasing pollution and overall problems in managing the resource have contributed to further deterioration in the situation. The overall water problems in the ESCWA region can be attributed to the following:

- Natural water scarcity owing to the arid, semi-arid and extremely arid climates;
- Lack of up-to-date information on the quantity and quality of available and potential water resources and of reliable forecasts on water demand;
- The general absence of comprehensive national planning and well-designed policies for water resource exploitation and use and demand projections with overall socio-economic development plans;
- Lack of awareness in the public sector of the need for the rational use and management of water resources;
- Outdated water legislation and non-existent enforcement mechanisms;
- Fragmented water institutions and ineffective coordination of related water activities at the national level;
- The absence of technical cooperation between ESCWA member countries at the regional or subregional level in the exploration and development of new resources, particularly of shared rivers or groundwater basins;
- Lack of adequate financial resources to efficiently develop non-conventional water resources, particularly desalination and wastewater reuse facilities, as well as hydraulic structures and distribution systems.

As a result of chronic water shortages, excessive consumption and increasing pollution, water professionals and decision makers are being confronted with the major challenge of managing water resources. Demand for water already outstrips supply in a number of countries, and the gap is expected to widen in the immediate future. Water availability is already approaching its development limit, and the provision of additional water, especially from non-conventional sources, is increasingly costly. Effective management of all water sources has not complemented significant achievements in the provision of adequate and safe water supplies.

During the past 25 years, the countries of the ESCWA region have concentrated their water programmes on the development of both water resources and infrastructure. Water withdrawal in a number of countries has exceeded the sustainable limit. Shortages have become acute in the region, except in countries with major rivers. Non-conventional water resources such as desalinated sea water, treated wastewater and irrigation drainage water have been used in some countries such as the GCC countries, Egypt and Syria to supplement natural resources in the domestic, industrial and agricultural sectors.

Development programmes in the water sector have contributed to increased water consumption and the depletion of water resources. Little effort has been made to manage water resources or to establish short-term or long-term strategies or policies to avert future shortages. Furthermore, decision makers in the public sector have failed to acknowledge the importance of supply and demand management measures as essential tools in the reduction of shortages and the conservation of water for future generations.

TABLE 1. RENEWABLE WATER RESOURCES AND PROJECTED POPULATION IN THE ESCWA REGION

Country/area	Population (million)[a/] 2000	2010	2025	Annual renewable water (conventional water resource) (bm^3) Surf. wat.	GW	Total	Availability (m^3 per person per year) 2000	2010	2025
Bahrain	0.613	0.689	0.789	0.002	0.100	0.102	163	145	127
Egypt	68.523	80.368	96.463	55 500	4 100	59.600	870	742	618
Iraq	23.280	31.071	43.482	70 370[b/]	2 000	72.370	3 109	2 329	1 664
Jordan	5.003	6.747	9.620	350	277	0.627	125	93	65
Kuwait	2.165	2.339	2.721	0.1	160	0.160	74	68	59
Lebanon	3.282	3.723	4.400	2 500	600	3.100	945	833	705
Oman	2.518	3.423	5.019	918	550	1.468	583	429	292
Palestine	2.859	3.972	5.987	30	185	0.215	371	271	276
Qatar	0.579	0.793	0.779	1.4	85	0.086	30	22	14
Saudi Arabia	21.930	31.363	54.029	2 230	3 850	6.080	277	194	113
Syrian Arab Republic	16.125	20.464	26.292	16 375[b/]	5 100	21.475	1 332	1049	817
United Arab Emirates	2.442	2.851	3.284	185	130	0.315	129	110	96
Yemen	18.654	28.661	44.036	2 250	1 400	3.650	196	127	83
Totals/averages	167.973	216.464	296.901	150.71	18.54	169.247	1 008	782	570

Source: ESCWA, "Updating the assessment of water resources in ESCWA member States", Expert Group Meeting on Updating the Assessment of Water Resources in ESCWA Member States, Beirut, 20-23 April 1999 (E/ESCWA/ENR/1999/WG.1/7).

a/ Based on United Nations Secretariat, Department of Economic and Socila Affairs, Population Division, World Population Prospects: The 1996 Revision (ESA/P/WP.138), later republished as (ST/ESA/SER.A/167).

b/ The flow of the Tigris and Euphrates rivers can be reduced by upstream abstraction in Turkey.

Some important demand management components such as public education, water-saving technology, effective plumbing codes and regulations, and water pricing have been implemented in a fragmented fashion; efforts have been neither comprehensive nor integrated. The same is true of supply management by such means as supply augmentation through artificial recharge schemes, weather modification, system rehabilitation, the reuse of wastewater, and protection programmes. Such resource enhancement measures have been implemented only infrequently in some countries of the region. Fragmented implementation has interfered with the optimal development and utilization of natural water, desalinated water and treated wastewater resources.

In light of the above, implementation of the following measures is recommended (ESCWA 2003):

(a) Strategic plans for meeting future water requirements must include the application of an Integrated Water Resources Management (IWRM) approach at all levels. Member states in the ESCWA region should develop and manage their water resources in an integrated manner within the context of their economic and social development objectives, and in line with the provisions of chapter 18 of Agenda 21. Effective integrated water resource management requires clearly defined long-term policies and strategies set forth in national water plans, as well as institutional and legal tools for the efficient and equitable allocation of resources. High priority must be given to surface water and groundwater sources shared between riparian states, so that binding agreements and treaties on both water allocation and quality, may be concluded based on international water law;

(b) Governments of the region are encouraged to create a favorable investment environment to attract private sector participation in financing and administering the water and sanitation infrastructure, including agricultural projects. Action required in this respect includes the development of a clear and comprehensive policy as well as a flexible and effective administrative and legal framework.

(c) The agricultural sector, as the major water consumer in the region, should be the focus of extensive conservation efforts.

B. The Status of Water resources and Demands in The ESCWA Region

Water resource issues are probably more significant in the ESCWA region than in any other part of the world because of the scarcity of water and its mismanagement. When projected water requirements for all purposes are compared with available surface and groundwater resources, serious questions arise as to the long-term economic and environmental sustainability of existing water resource development and water usage patterns. Under existing patterns of water usage and prevailing water scarcity, it is unlikely that the expansion of irrigated agriculture can proceed without leading to water shortages, especially in the domestic sector.

Water resources consist of surface water from major rivers in Egypt, Iraq, Syria, Lebanon and Jordan, estimated at 150.7 billion cubic meters (BCM) and renewable groundwater in shallow aquifers with limited reserves receiving recharge at 18.7 BCM. There are significant reserves in deep aquifers with fossil water and poor water quality. Treated wastewater and drainage water is estimated at 8.3 BCM and desalinated water at 2.1 BCM. In 2000, total consumption was 150.5 BCM, use of groundwater being 30 BCM. The water resources of the ESCWA region are shown in Table 2.

Total water demand during the past two decades has increased dramatically in ESCWA countries as a result of high population growth, urban migration, improvement in the quality of life, efforts to establish food self-sufficiency, and industrial development. Agriculture is the primary water consumer, representing 86 per cent of total water demand for the region in 1997. Total water demand for domestic, industrial and agricultural purposes in the ESCWA region amounted to 140 BCM in 1990 and was estimated at 181 BCM for 2000, as shown in Table 3. Total water demand is estimated at 181.1 BCM in 2000 and 261.8 BCM by the year 2025. Domestic and industrial water demand was expected to reach a total of 30.4 BCM and 55.5 BCM in 2000 and 2025, respectively (Country papers, 1995, 1997, 1999; ESCWA, 1992, 1995, 1997b).

Industrial activities in most of the ESCWA member countries have also contributed to the increase in total water requirements, though not as dramatically as agricultural activities. In 1990, industrial water demand in Egypt, Iraq, Jordan, Lebanon, the Syrian Arab Republic, and the West Bank and Gaza Strip totaled 6.3 BCM, and only 0.3 BCM in the GCC countries and Yemen. Industrial demand for the whole region as a whole amounted to 6.7 BCM in 1993 and 8.6 BCM in 1997. Industrial water demand accounted for between 0.4 and 11.3 per cent of total demand, the smaller percentages being reported for the GCC countries. Countries with a relatively well-established industrial infrastructure include Egypt, Iraq and the Syrian Arab Republic. Industry is still fairly limited in the southern part of the region. Industrial demand is projected to reach 9.4 and 18.6 BCM in the years 2000 and 2025, respectively, with the highest demand in Egypt, Iraq and the Syrian Arab Republic (Country papers, 1997, 1999; ESCWA, 1995, 1997a).

Agricultural water requirements account for most of the water used in the ESCWA region. Demand reached 123.2 BCM in 1990, increasing to 136.5 BCM in 1997, and estimated at 150.7 and 206.3 BCM in the years 2000 and 2025, respectively. By all measures, the ESCWA region is considered one of the most water-stressed areas in the world, and its long-term water situation is becoming increasingly uncertain. Water balances either already slumped into serious deficit in some countries, such as Saudi Arabia, Jordan, Bahrain and Yemen, or are moving in this direction. The water utilization rates demonstrate the extent to which some countries in the region are living beyond the levels of their renewable water resources by utilizing non-conventional sources of water and/or over-drawing their groundwater aquifers (ESCWA, 2001).

Unless fundamental changes are introduced to improve water resources management, a vicious circle could begin: water shortages will adversely affect economic growth; and slower growth, in turn, will reduce the investment needed to increase water availability. ESCWA member countries are left with one option: to manage their water resources efficiently, to reduce the gap between supply and demand and ensure sustainability of those resources. Fortunately, most of the governments in the region recognize the urgency of addressing the problem before it gets worse and are now giving serious consideration to water policy and institutional reforms. National and international efforts have been mobilized to curb the water crisis in some ESCWA member states, such as Jordan, Yemen and the West Bank and Gaza Strip. Frequently, however, traditionally fragmented water management approaches along with heavily subsidized water supply have weakened the effectiveness of the reform measures being taken (ESCWA, 2001).

Water is a unitary resource that should be managed in an integrated manner to reflect the needs of all social, economic, environmental and public health targets of the country. The module will assist water managers and engineers to formulate a water resources management framework and initiate actions based on the IWRM principals and dimensions (that are environmentally, socially, politically, economically sustainable) to improve and manage the water sector. The exercise of this module suggests a paradigm for a comprehensive management framework for large-scale water management problems in ESCWA countries. This management framework can help to achieve sustainable water resources for meeting water demand and preventing the gridlock and excessive legal expense of uncoordinated and conflict-filled decision processes. This module is presented to identify attributes of the paradigm and explain how it can be applied. Physical interactions of the ground and surface water systems, environment, politics, economics, and sociological requirements will be integrated and quantified into the management framework.

Balancing supply and demand includes two basic components: a conceptual framework (which include problem identification, choice of objectives, screening of options, formulation of promising strategies and evaluation of strategies), and a computational framework (consisting of a detailed calculation procedure). In general, a number of essential steps in ESCWA countries towards balancing supply and demand should be taken into consideration:

1. Definition of objectives, assessment of available water resources and analysis of water demands.
2. Development and definition of options for solution considering:
    a- Environmental, economical, social, and legal aspects
    b- Institutional consideration and public participation
3. Generation of options
4. Choice of optimal option.

TABLE 2. SUMMARY OF AVAILABLE WATER RESOURCES, WATER CONSUMPTION, AND GROUNDWATER DEPENDENCY IN THE ESCWA REGION (MCM)

	Conventional water resources[/,b/,c/]				Non-conventional water resources					
Country/area	Surface water	Ground-water use	Ground-water recharge	Total renewable (MCM)	Desalinated water	Waste-water and drainage reuse	Total renewable and non-conv. res., (MCM)	Water consump.	Utilization %	Groundwater dependency (%)
Bahrain	0.2	258	100	100.2	75	17.5 (3)*	192.7	350.7	181.99	73.57
Egypt	55 500	4 850	4 100	59 600	6.6	4920 (3800)	64526.6	65 276.6	101.16	7.43
Iraq	70 370	513	2 000	72 370	7.4	1500	73877.4	72 390.4	97.99	0.71
Jordan	350	486	277	627	2.5	61	690.5	899.5	130.27	54.03
Kuwait	0.1	405	160	160.1	388	30	578.1	823.1	142.38	49.2
Lebanon	2 500	240	600	3 100	1.7	2	3103.7	2743.7	88.4	8.75
Oman	918	1 644	550	1 468	51	23	1542.0	2636.0	170.95	62.37
Qatar	1.4	185	85	215	131	28	245.4	345.4	140.75	53.56
Saudi Arabia	2 230	14 430	3 850	86.4	795	131 (24)	7006.0	17 586.0	251.01	82.05
Syrian Arab Republic	16 375	3 500	5 100	6 080	2	1447 (1270)	1447.0	21 324.0	93.02	16.41
United Arab Emirates	185	900	130	21 475	455	108	878.0	1 648.0	187.7	16.41
West Bank & Gaza	30	200	185	315	0.5	2	217.5	232.5	106.9	54.61
Yemen	2 250	2 200	1 400	3 650	9	52	3711.0	4511.0	121.56	86.02
Total	150 709.7	29 811	18537.0	169 246.7	1924.7	8321.5	179492.9	190 766.9		48.77

Source: Compiled by the ESCWA Secretariat from country papers, EGM and international sources 1995, 1996, 1997, and 1999.

* *Volume of drainage water.*

a/ *The flow of the Tigris and Euphrates rivers may be reduced by upstream abstraction in Turkey.*

b/ *ACSAD paper submitted to the 2nd Symposium on Water Resources Development and Uses in the Arab World, Kuwait, 8-10 March 1997.*

c/ *Consolidated Arab Economic Report, 1997.*

TABLE 3. PAST AND PROJECTED WATER DEMAND FOR THE ESCWA REGION, 1990, 2000 AND 2025 (MCM)

Country/area	**1990**			**2000**			**2025**			**Total demand**		
	Domestic	**Agric**	**Industrial**	**Domestic**	**Agric**	**Industrial**	**Domestic**	**Agric**	**Industrial**	**1990**	**2000**	**2025**
Bahrain	112	120	17	132	124	26	169	271	169	249	282	609
Egypt	2 700	49 700	4 600	2 950	59 900	5 350	6 300	69 100	10 900	57 000	68 200	86 300
Iraq	3 800	45 200	1 450	4 300	52 000	9 700	8 000	90 000	10 000	50 450	66 000	108 000
Jordan	190	650	43	388	791	63	700	900	160	883	1 242	1 760
Kuwait	295	80	8	375	110	105	1 100	140	160	383	590	1 400
Lebanon	271	875	65	312	950	150	1 100	2 300	450	1 211	1 412	3 850
Oman	117	1 150	5	262	1 500	85	630	1 500	350	1 272	1 847	2 480
Qatar	107	109	9	147	185	15	230	205	50	225	347	485
Saudi Arabia	1 508	14 600	192	2 350	15 000	415	6 450	16 300	1 450	16 300	17 765	24 200
Syrian Arab Republic	650	6 930	146	1 280	15 370	480	2 825	19 430	1 300	7 726	17 130	23 555
United Arab Emirates	513	950	27	750	1 400	30	1 100	2 050	50	1 490	2 180	3 200
West Bank and Gaza Strip	78	140	7	260	217	18	800	420	70	225	495	1 290
Yemen	168	2 700	31	360	3 150	61	840	3650	134	2 899	3 571	4 624
Total	10 509	123 204	6 600	13 866	150 697	16 498	30 244	206 266	25 243	140 313	181 061	261 753

Source: Compiled by the ESCWA secretariat from country papers, regional and international sources (1992, 1994, 1995, 1996, 1997 and 1999), and questionnaires.

C. DEFINITION OF OBJECTIVES, ASSESSMENT OF AVAILABLE WATER RESOURCES AND ANALYSIS OF WATER DEMANDS

For any area, the first step in planning and managing water resources is the development of water supply/demand projections and preparing water strategy and then select options considering population growth versus demand growth. The time of the analysis should reach as far into the future as population growth in a given area can be forecasted with reasonable accuracy. This will depend on availability and reliability of statistical projections, particularly demographic data on population, land use, employment, industrial development, housing, etc., and data on municipal, industrial, and agricultural.

Balancing supply and demand, consists of three inter-linked activities, which are:

1. *Water Demand analysis*, which, as its name implies, calculates the projected water demands based on economic, demographic and technological assumptions. (*Module 9 will discuss water demands: modeling and management*).

2. *Water resources assessment* (WRA): There are many methods and approaches to water resources yield evaluation (or assessment). The most reliable WRA framework is provided in the UNESCO/World Water Assessment Program (WWAP) and UNECSO/World meteorological organization (WMO) Manual. This is a UN wide program with UNESCO designated as the head agency, which seeks to develop the tools and skills needed to achieve a better understanding of basic processes, management practices, and policies that will help improve the supply and quality of global freshwater resources.

3. *Balancing supply and demand* to develop the optimal option based on a given set of demands and specific constraints.

WRA involves taking a holistic view of the water resources in a given country or region related to its use by society. The assessment looks at both the quantity and quality of surface- and groundwater. It identifies the pertinent parameters of the hydrological cycle, and evaluates the water requirement of different development alternatives. WRA is a tool to evaluate water resources in relation to a reference frame, or evaluate the dynamics of the water resource in relation to human impacts or demand. WRA is applied to a unit such as a catchment, sub-catchment or groundwater reservoir. It is part of the IWRM approach, linking social and economic factors to the sustainability of water resources and associated ecosystems. Depending on the objective of the assessment, WRA may look at a range of physical, chemical and biological features in assessing the dynamics of the resource (GWP 2001).

Traditional water resource assessment aim to provide the information basis for the supply of infrastructure to meet projected needs. Assessments have much wider functions and purposes in an IWRM perspective, incorporating cross-sectoral tools such as:

- Demand assessment, which examines the competing uses of water with the physical resource base and assesses demand for water (at a given price), thus helping to determine the financial resources available for water resource management.
- Environmental impact assessment and Strategic impact assessment collect which data on the social and environmental implications of development programs and projects. EIA is an important tool for cross-sectoral integration involving project developers, water managers, decision-makers and the public. It can be seen as a special form of water resources assessment.
- Social impact assessment, which examines how social and institutional structures affect water use and management, or how a specific project might affect social structures.
- Risk or vulnerability assessment, looking at the likelihood of extreme events, such as flood and droughts, and the vulnerability of society to them.

A sound water resources assessment needs to be based on accurate and reliable physical and socio-economic data. Routine physical measurements at monitoring and gauging stations need to be made at appropriate times and often enough to allow the assessment to draw valid conclusions. This in turn requires adequate financing of the monitoring system by government. Socio-economic aspects must include analysis of user behavior, elasticity of demand, and the potential effects of demand management. Water resources assessment for IWRM sets the hydrology in a wider context and considers social and economic development issues such as urban growth and changing land use patterns (GWP 2001).

Water resources knowledge base is an important tool for the assessment of water resources. This tool covers the collection and storage of data on the hydrological cycle (quantity and quality) and access to physical, socio-economic, demographic and water use data in a cross-sectoral perspective. The need to share knowledge is growing rapidly in a world where the Internet and email allow for ease of interaction as never before. The holistic nature of IWRM requires constant knowledge exchange by water stakeholders, and especially professional water practitioners. There is a need to develop indicators to measure progress towards achieving sustainable use of water resources.

Building a knowledge base into an effective tool requires consistent, routine work over large areas and many years. It also requires the development of working relations and data exchange between sector institutions representing either impacts on water resources or use of water resources. Thus it is important that data collection staff work in a coordinated fashion with those working on water resource assessment, so that data accurately reflect the current situation and reliably pinpoint the problems.

Modeling can be used to study impacts and trends resulting from various development options. However, for models to be useful in the pursuit of sustainable solutions, they must address and simulate not only economic efficiency and technical merits, but also the preferences and priorities of stakeholders. Models will be truly useful when they are integrated into the local institutional and cultural contexts.

D. OPTIONS FOR CLOSING THE SUPPLY DEMAND GAP IN ESCWA COUNTRIES

The growing disparity between water supply and demand calls for shifting emphasis in water management from supply to demand management. Empirical evidence from a number of countries indicates that under varying conditions, the "next" best source of water is often that which can be saved in almost any system. Saving water through demand management tools policies should always be pursued, even when investments are made in water development projects, i.e. supply augmentation. In these projects, economic efficiency and environmental sustainability should compliment each other and include demand management tools, e.g. prevent pollution, and reduce sensitivity to emergencies such as drought. "R*esponding to water shortages by increasing supplies through capital intensive water transfer or diversion projects has already clearly reached its financial, legal and environmental limits. Attention must now shift from development to management." (World Bank, 1991)*

The options for closing the gap between supply and demand should include the following strategic options. (Le Moigne et.al. 1994):

- Broad technical arrangements to meet physical developments of water resources.
- Options for institutional and human resource development, involving water users, non-government organizations, professionals, and local government in water resources management.
- Requirements and alternative means for capacity building in institutions and skills for water sector management.
- Environmental and health protection measures.
- Long term forecasts of supply and demand within national water resources plans and strategy;
- Developing leakage strategies and identifying technical, institutional and financial requirements for implementing them;
- Promote water conservation as a vital component of IWRM and saving measures and economic benefits in all sectors;
- Reallocation policies among competing sectors;

- Effective legislation and water use regulations especially for groundwater withdrawal;
- Costing, pricing and tariffs design which address affordability issues to limited income groups;
- Supply side and demand side technologies;
- Promote water efficiency plans for all customer, households, business, farmers and industry
- Quantify and survey impacts on supply/demand costs, benefits and risk options;

Table 4 below summarizes the various strategic options existing in some ESCWA countries. Supply augmentation, with emphasis on non-conventional sources of water supply remains a favoured policy option in all countries. The capacity of water desalination has increased dramatically and is expected to continue to expand in the future, despite its relatively high cost. Use of treated wastewater is also encouraged, especially in the agriculture sector (ESCWA 2001).

Demand management tools are varied and concentrate on increasing water efficiency through the use of technical tools and cost recovery, demand reform policies. Demand management is acknowledged as an essential component of sustainable development, however water professionals in the region still lack a good commend of all economic and financial tools; and these tools have not been adequately researched and tested in terms of their long-term effects on the patterns of water use and water quality. All the countries in the region admit to the necessity of cost recovery through water charges and tariffs and many of them are now applying progressive water tariffs. An increasing number of countries (Jordan, the Syrian Arab Republic, Iraq, Bahrain, Lebanon, the West Bank and Gaza Strip) are also implementing water tariffs for irrigation, although they fall short of covering O&M costs, while others (Egypt, for instance) are still reluctant to impose any charges on irrigation water use. (ESCWA 2001).

TABLE 4. THE MAIN STRATEGIC OPTIONS IN VARIOUS COUNTRIES OF THE ESCWA REGION

Strategic options	
I. Options for an optimal utilization of the existing water resources	**In countries**
Increasing water efficiency through the minimization of water losses in all uses of surface and groundwater sources and leakage control.	Egypt, Jordan, Bahrain, the Syrian Arab Republic, Saudi Arabia, Yemen, United Arab Emirates, Lebanon
Motivating the use of water-saving devices in the household and industrial sectors	Jordan and Saudi Arabia
Re-structuring domestic water tariffs to cover at least O&M costs	Egypt, Jordan, the Syrian Arab Republic, Lebanon, Bahrain, Yemen, the West Bank and Gaza Strip
Re-structuring irrigation water tariffs to cover at least O&M costs	Jordan, Lebanon, Bahrain, the Syrian Arab Republic, the West Bank and Gaza Strip Iraq
Introducing different sorts of water rationing	Jordan and Bahrain
Involving "water users associations"	Egypt, the Syrian Arab Republic, Oman, Yemen
Setting up a cost-recovery system in which water-users pay for the services of water distribution and network maintenance	Egypt and the Syrian Arab Republic
Changing the cropping pattern	Egypt, the Syrian Arab Republic, United Arab Emirates, Saudi Arabia, Bahrain, Yemen
Switching certain crops to brackish water irrigation	Saudi Arabia, United Arab Emirates, Bahrain, Yemen
Maintaining the safe yield of groundwater aquifers, by setting up regulatory and financial measures to control and reduce the over-abstraction	Jordan and Yemen
Encouraging rain-fed agriculture	Yemen and the Syrian Arab Republic
Installing a metering system for underground water use	Jordan, Bahrain, Saudi Arabia, the Syrian Arab Republic, Yemen
Reusing agriculture drainage water to meet part of the irrigation demands	Egypt, the Syrian Arab Republic, Saudi Arabia
Pollution control of water and water projects rehabilitation	Jordan, Palestine, Yemen,
Regulating water markets	Yemen
Transferring part of the water out of agriculture uses	Yemen
Reusing treated industrial water	Jordan and Yemen
Reusing sewage water in cultivating non-food crops	Egypt, Jordan, Saudi Arabia, United Arab Emirates, Bahrain, the Syrian Arab Republic, Yemen
Increasing the role of the private sector in the investment and maintenance operations of water supply through BOT, BOO and other privatization techniques	Some of the GCC countries and Yemen
Sectoral water Allocation policies	Egypt, Jordan, Saudi Arabia, Palestine
Increasing the role of the private sector in the investment and maintenance operation of water utilities through BOT, BOO and other privatization techniques	Egypt, Jordan, Lebanon, Bahrain, Yemen
Establishing recharge dams and other hydrological structures to increase reservoir of groundwater	Lebanon, Bahrain, the Syrian Arab Republic, Yemen, United Arab Emirates
Cloud seeding/harvesting	The Syrian Arab Republic and Yemen
Desalination of sea water	All GCC countries and Yemen

Strategic options	In countries
II. Options for developing new water resources	
Desalination of brackish groundwater	Egypt
Assessing the potential of utilizing brackish water	Jordan
Harvesting rainfall and flash flood waters	Egypt
Evaluating groundwater and surface water potentialities, especially in critical basins	Jordan
Investigating use of seawater for cooling machines	Lebanon
Rainwater Harvesting	Lebanon, the Syrian Arab Republic, Jordan, Palestine
Encouraging research on artificial recharging of aquifers to increase groundwater supply	Jordan, and Kuwait
Increasing the country's share of the joint sources of water through implementing joint projects with other countries sharing the same water basin	Egypt, Bahrain, Jordan, the West Bank and Gaza Strip
III. Options for water quality management	
Treating industrial wastewater before discharging it into the river or other water bodies	Egypt, Jordan, Yemen
Collecting domestic sewage and treating it before it is discharged back into the system	Egypt, Jordan, GCC countries, Yemen
Controlling and reducing the amount of agrochemicals (fertilizers, pesticides and the other added chemicals)	Egypt
Expanding well-field protection zones	Bahrain
Carrying out an environmental impact assessment for each water project	The West Bank and Gaza Strip
Controlling sea-water intrusion	Egypt and GCC countries
Legally obliging river cruises to treat their wastewater during navigation before discharging	Egypt
IV. Options for capacity building and creating a better environment for potential reforms in water management	In countries
Enhancing training and increasing skills of human resources in the water sector	All countries
Improving data and information systems	All countries
Restructuring water institutions to achieve financial and administrative decentralization and autonomy	Jordan, the West Bank and Gaza Strip, Yemen
Updating legislation, reviewing regulations and enhancing enforcement	Lebanon, Egypt, Yemen, Bahrain, Saudi Arabia, United Arab Emirates
Initiating an intensive public awareness programme to stimulate water conservation	Egypt, Jordan, Saudi Arabia, United Arab Emirates, Bahrain, Yemen, the West Bank and Gaza Strip.
Encouraging research in the field of water use in the different local sectors	United Arab Emirates, Kuwait, Jordan
Including water resources and their costs as a basic criterion for the evaluation of projects and economic plans	Yemen and Jordan

Source: *ESCWA. (1999). Current water policies and practices in selected ESCWA member countries, E/ESCWA/ENR/1999/15.*

What is missing in the ESCWA region?

While the above policy option give some indications that countries in the region are attempting to address issues of sustainable development of water from different angles, however these options should not be the ultimate objective of a water-stressed country; the real target is the screening and selection of the best options and successful implementation to correct the increasing imbalance between water demand and supply. Many of the options included in the water management strategies of Yemen, Egypt, the West Bank and Gaza Strip, Oman and Jordan are nicely articulated, but will be hard to put into a practical framework within a short period of time. However, to switch to water demand management measures, or at least to include them in the management of water resources, many political, social, financial, economical, environmental and technical issues and obstacles will need to be addressed and resolved. In varying degrees, many deficiencies and gaps still exist in the prevailing economic, social, legal and institutional structures of ESCWA member countries, which will have to be bridged to open the road to integrated water management. To elaborate:

(a) Most of the supply augmentation options and part of the demand management techniques require undertaking huge capital intensive projects, which will need a considerable amount of investment funds. Therefore, sources of finance should be clearly specified and planned from the beginning.

(b) The adequate monitoring of the exploitation of wells and surface water uses is extremely important for a satisfactory implementation of the strategic options. This requires not only availability of funds and physical equipment, but also qualified and highly motivated human begins who are committed to their monitoring activities;

(c) In addition to the financial barriers that may hamper the implementation of the adopted strategies, social barriers may also pose a constraint to many aspects of water demand management, such as the reuse of treated wastewater in the agriculture sector.

(d) Public health, environmental, economic, social and health objectives are not given enough consideration in the proposed and adopted options. According to different sources of information, no intensive and adequate studies have been conducted to assess the impact of the water resources strategy on the environment and the public health.

(e) The management of water resources is fragmented between multiple sectors and institutions with different objectives. In the implementation of IWRM approach at the national level there is a need to identify the exact mix of tools and policy options and investments needed in a given context. This will be based on level of development, climate, relative water scarcity, level of agricultural intensification, and clear definition of water rights and enforcement strategy of local organizations, decision support system as well as existing institutional arrangements and their capacity to implement plans and enforce legislation.

(f) All countries in the regions extensively relied on their governments for water collection, treatment, conveyance, distribution and disposal. As a result, the central agencies became overwhelmed with the size of their administrative and financial responsibilities.

(g) The monitoring of quantity and quality of water resources is either lacking or not effectively practiced.

(h) Part of the efficacy of a long-term water resources management options depends on the accuracy of anticipating future conditions in the three closely related areas of economic, social and environmental circumstances. Such projections are determined by the quantity and quality of the data and information available on these aspects, which in turn depend on the existing information system. In most cases in the ESCWA region, the quality, quantity and organization of the existing information system are inadequate.

Box 1 - Case Study on Amman Zarqa Basin – Using Reclaimed Water to Bridge the Gap Between Supply and Demand

This case demonstrates use of IWRM tools to incorporate water and its re-use in water resource planning and balancing supply and demand in the Amman Zarqa basin in Jordan, working with farmers' groups.

Main IWRM Tools

- C1. WATER RESOURCES ASSESSMENT - Understanding resources and needs

C1.2 Water resources assessment

- C2. PLANS FOR IWRM - Combining development options, resource use and human interaction

C2.2 Basin Management Plans

- C4. SOCIAL CHANGE INSTRUMENTS – Encouraging a water-oriented society

C4.2 Communication with stakeholders

- C6. REGULATORY INSTRUMENTS - Allocation and water use limits

C6.1 Regulations for water quality

Description

Jordan's renewable water resources are currently being exploited at a rate far in excess of the sustainable yield. The Jordan Valley is chronically short of irrigation water, and current freshwater supplies will increasingly be diverted from irrigation to meet the growing demand for municipal and industrial use in the greater Amman area. However, the annual volume of reclaimed water is expected to triple in the next 25 years. Social stigma and inability to control water quality have hampered planning hitherto. A 25-year draft Reclaimed Water Utilization Plan has been prepared to support implementation of Jordan's water policies. The draft Plan focused on the Amman-Zarqa Basin. Development of the Plan required open discussion about acceptable use of reclaimed water and the appropriate standards, regulations to safeguard health and the environment, and potential impact on markets for irrigated crops. It required examination of a wide range of interrelated water use and management options from industrial applications and replacing groundwater used for irrigation in the highlands, to replacing freshwater currently used in the Jordan valley for irrigation with reclaimed water. The key objectives of the Plan are to use reclaimed water, where practical, to exchange for present and future uses of freshwater, and to maximize the returns from the reclaimed water resource. In addition, the plan considered other requirements such as protecting the public, conserving resources, complying with international treaties, and ensuring environmentally sound practices. Plans for using reclaimed water were best explained and were more readily accepted when "supporting actions" are developed and presented as an integral part of the plans. Supporting actions included: proposals for improved on-farm water management, a regulatory framework, water quality improvement plans, monitoring and information management, and crop marketing plans.

Lessons learned

- Proposals to replace good quality freshwater with reclaimed water for irrigation were strongly resisted until standards for water quality and regulatory processes were proposed to ensure crop marketability.
- Irrigation with reclaimed water is viable but salt and chloride levels must be controlled.
- Reduction of salt levels in the municipal water supply will benefit irrigated agriculture using reclaimed water and establishes urgency for investing in a new, high-quality, fresh water supply for municipal use.
- Standards and regulations tailored to specific uses gain wider acceptance than one standard for all uses.

Importance of case for IWRM

Disposal of treated wastewater is frequently considered a problem. This case demonstrates the use of various IWRM management instruments to balance supply and demand, to assign value to reclaimed water and incorporate this water resource into overall water resource planning in ways that gain public support.

Source: GWP ToolBox - Case study No. 79, 2003

E. DESCRIPTION OF PLANNING CRITERIA

The multi-disciplinarity of IWRM has made the planning process much more complex than ever before. This complexity makes it more difficult to adopt a well-integrated methodology for quantifying social, political, economical environmental, institutional and community goals, and measuring them or determining what they should be.

In developing and analyzing options and making policy recommendations, the water resources manager must strike a balance between the ideal and the practical forms of water resources management for a country. The manager should in any event avoid producing a list of options and recommendations, that are a "wish-list", divorced from practical considerations of the resources available to implement a water resources strategy.

Some of the factors shaping the options for reducing the gap between supply and demand include: the amount and timing of the capital investment required, operating and maintenance cost. The assessment criteria used to rank the different options to meet the future national and regional water demand in terms of quantity and quality depend on the technical aspects, financial aspects (Modules 5 & 10), environmental impacts (Module 7), social and political implications and institutional aspects (Modules3 & 4).

Planning criteria set the framework for decision- making regarding the development and selection of "best" options for a specific area to implement an IWRM strategy. The criteria discussed hereafter can be considered as a base line; it is possible to add other criteria if a given context necessitate so. The criteria can be classified in to the following categories: (CDM 1997):

E.1. Financial viability

Financial analysis plays a major role in assessing the different development options. There is a need to analyze financial aspects of the option within the context of an investment plan prioritizing needs in the water sector and in particular for the provision of water and sanitation services to population to achieve the target of Millennium Declaration Goal. This category includes the following sub-criteria:

1. Fundability

As less expensive local sources of water become fully developed, additional supplies can generally be made available only through development of more expensive and often more distant sources. Since available funding for water resources development is always scarce, it is important that the total cost of water supply options be within the capabilities of the government.

2. Unit cost of water, dollars per cubic meter

Competing options may be evaluated based on the overall cost (i.e., capital investment and recurrent costs). However, since water demand may not be inelastic to the price of water, and since costs are not fixed over time, it may be more appropriate to use the cost of a unit of water for evaluating competing water resource options. This criterion, which is a measure of efficiency of options, can be obtained from a cost/benefit analysis.

3. Affordability

Water supplies for all uses must be reasonably priced. Water that has too high a price for a given use will be unavailable to some potential users, and water that is under priced will attract a demand that may exceed the quantity that can be supplied. A subsidy of water supply risks over-use of the resource and can lead to a degradation of the supply system if the full costs of operation and maintenance are not recovered from the users. It is, therefore, important that water supplies be obtained at a cost to the user that is consistent with the value of the water to the user, and at a price that generates sufficient revenue to provide for operation and maintenance costs. (Modules 5 & 10)

E.2. Technical viability

Criteria included in this category are:

1. Availability of technology

Some proposed large-scale water import schemes are usually capital intensive and rely on complex and advanced technologies, which in many cases have not been fully researched. These technologies involve higher costs and greater risks.

2. Implementability

Considerations such as availability and accuracy of data, existing infrastructure, manpower, expertise, reasonable time schedule for implementation, equipment, level of effort, energy form needed for operation and its source, and land requirements are important boundary conditions for successfully adapting water supply technologies. Invariably, some technologies require a level of effort or equipment that may be available locally, whereas others may necessitate the import of specialized contractors or manpower. Implemetability is also affected by existing legislation, regulation and ability of concerned institutions to enforce them.

3. Flexibility and reliability of technology

This criterion is a measure of the ability of technologies to meet the design objectives, the ability for expansion and modifications to meet future demands, and susceptibility to failures and breakdowns.

4. Feasibility

This criterion is a measure of the relative complexity of constructing, operating, and maintaining the various technologies and components of water resources options.

5. Water resources knowledge

Water resources knowledge base is an important tool for the assessment of an option. This tool covers the collection and storage of data on the hydrological cycle (quantity and quality) and access to physical, socio-economic, demographic and water use data in a cross-sectoral perspective.

E.3. Source viability

Criteria included in this category are:

1. Availability and hydrologic certainty of the source

Water sources that have a relatively high degree of uncertainty in their supply, due to hydrologic randomness, are less desirable than those, which are predictable. Since it is critical that investments in the development of new water supply sources have a high probability of success, it is important for those sources to be hydrologically dependable.

2. Sustainability of quantity and quality

It is important that selected options provide significant quantities of water in relation to the total unsatisfied demand, and sustain these quantities during the planning period. Water from various sources may have different qualities. It is essential, thus, that the quality of supplied water meet the established standards for the intended use, and that this quality be sustainable.

3. Flexibility of Supply development

This criterion is a measure of the potential expandability for further developing the source to accommodate growing future demands. Options that offer easy or modular expandability of water supply and which are not restricted to operation in particular or limited locations are relatively more attractive.

E.4 Political viability

Political viability includes political constraints and risks, mobilization of public opinion to accept or reject selected option and risk and opportunities emanating from political events at national or regional scale. Often a political process and the real decision-making lie with politicians. Political implications encompass the following criteria:

1. Willingness of participants
Most of the large-scale water import schemes require the participation of several countries in the acquisition and transportation of water. The ultimate success of any such plan necessitates long-term political and economic commitments on the part of all countries involved, as well as the development of institutions, which adhere to principles of international law, international water rights and management of conveyance systems.

2. Political certainty of the source country
This criterion pertains to the long-term political reliability of the commitment and stability of the source country. Thus, this criterion is a measure of the long-term accessibility to the source independently of the internal political situation of the source country.

3. Compatibility with the international laws and the existing agreements.
This criterion pertains to the compatibility of a given option with principles of riparian rights and notably international laws and existing agreements, conventions governing the use and exploitation of water resources and shared water resources.

E.5. Institutional viability

This aspect includes:

1. Structure and capacity of existing institutions
The short and long term success and sustainability of any water resources option is closely related to the structure and performance of existing water and water related institutions, and this ability to accommodate the increasing demand for water. Managerial, regulatory, legal, as well as technical and planning functions of these institutions must be evaluated in the process.

2. Reliability of institutions
It is incumbent upon these institutions to be effective, reliable, and efficient in administering and managing the required water delivery and treatment system. Accordingly, management and service-providing institutions should be financially viable, and able to provide services equitably in a timely and cost effective manner. There is a need to promote better and effective water resources governance arrangements and transparency, mechanisms for horizontal coordination among water institutions, decentralization, building stronger partnership between government, civil society and the private sector.

E.6. Environmental viability

Large-scale manipulations of the hydrologic cycle are likely to have beneficial and adverse impacts on the environment, particularly projects designed to expand water supply. Potential environmental impacts can be classified along the following themes: (OECD 1985):

1. Impacts on the built environment
Positive impacts include improvement of public health and hygiene as a result of increasing supplies to meet domestic water demands. Negative impacts include: (1) the increase of wastewater flows as a result of increasing water consumption; (2) generation of various waste steams such as disposal of brine water produced by desalination; (3) greater use of fuels for energy generation; (4) disturbing existing land use

patterns and ownership. Additional short-term adverse impacts could include noise pollution and traffic disruption during construction.

2. Impacts on the physical and natural environment
Potential impacts on the physical and natural environment may include: (1) reduction of groundwater and surface water flows and resources; (2) impacts on flora and fauna; (3) possible pollution from the output of chemicals and solid to soil, and land.

E.7. Social viability

The possible social impacts of each option need to be classified. This classification includes (OECD 1985):

1. Public acceptance
This criterion addresses public attitudes towards, and willingness to sustain additional costs associated with the introduction of new technologies or tariff structures. Ensuring public participation throughout the stages of planning and implementation, promoting awareness campaigns designed to explain and clarify proposed options and consolidating partnerships with stakeholders are some of the important mechanisms to reach public acceptance.

2. Fulfillment of development needs
Positive impacts of large-scale water supply and resources development encompass economic growth and social development due to: (1) job creation; (2) expected growth of water-reliant economic sectors such as agriculture and industry; (3) improvement of property values and quality of life.

F. SCREENING AND COMPARATIVE EVALUATION PROCEDURES

The major objective of this section is to discuss Multicriterion Decision Making (MCDM) techniques that can be applied to evaluate and choose optimal and applicable water resources management options in which discrete options are evaluated against criteria or factors.

A wide variety of tools are employed to address challenging decision problems in water resources management. Many of these techniques originated in the field of operation research addressing systems management problems related to water resources. By being cognizant of the main characteristics of the problems being studied, one can select one or more decision-making methods that match the characteristics of the actual problem (Duckstein et.al. 1982; Gershon and Duckstein 1984).

More than 70 MCDM techniques and 49 different criteria upon which the choice of an appropriate MCDM technique can be based are identified (Tecle, 1988). However, it would be very difficult for any one individual to possess the skills necessary to apply all the available techniques and evaluate them with respect to all criteria. Furthermore, experience in the use of a particular technique appears to be a pre-requisite for evaluating the technique with respect to a set of criteria.

Table 4 depicts the basic layout of the discrete version of an MCDM technique. In a sense, a multi-criterion tableau is like a spreadsheet on a computer for systematically organizing and presenting information about a problem. The evaluations of the criteria for each option reflect the objectives or preferences of the decision-maker. For each option, one has a row or column of *n* entries for comparing this option to the others in order to determine the set of preferred solutions. Most MCDM techniques differ in the types of information required for evaluating the options, as well as the definitions of the search procedures for finding the better solutions (Hiple 1992).

TABLE 5: TABLE USED IN MULTICRITERION DECISION MAKING, (A: ALTERNATIVES AND C: CRITERIA)

	A_1	A_2	....	A_n
C_1				
C_2				
C_n				

Source: Hiple, 1992

MCDM techniques for quantification of social and community goals range from simple visual procedures, rating and ranking methods, matrix and linear scoring methods, to multiple objective programming techniques.

The most appropriate technique for application to the type of problem identified in the watershed resources management is the rating technique, which is based on the "direct weighing" approach. Each general category will be assigned a weight (1 to 100) by each member of Water Focus Group, based on expert opinions (i.e., past experience and data from the literature), which can be obtained by distributing a questionnaire to each member of the Focus Group. Then the simple average weight can be obtained for each category. (The Water Focus Group is comprised of individuals who are involved and interested in the various aspects of water resources development, planning, management, research, and utilization.)

Screening the options requires the rating of each option according to agreed specifications with respect to its consistency or compatibility with each general category of criteria on an ascending scale of 1 to 10. After this qualitative rating, an overall score will be determined for proposed options, by calculating the product of the option rating for a given general criterion, times the criterion weight, and then summing these products across all general planning criteria. Symbolically, if w_i is the weight assigned to the i^{th} planning criterion by members of the Focus Group, and if r_{ij} is the rating of the j^{th} option with respect to the i^{th} criterion, the overall score, S_j, for the j^{th} option is calculated as:

$$S_j = \sum_{i=1}^{n} r_{ij} w_i$$

The scores, which will be obtained by various members of the Focus Group, will be summed to obtain an overall score for each option. Options with higher scores are ranked higher, and considered more compatible with the planning criteria than those with lower scores. The case study of this module presents an application of the above technique to a selected area.

G. PROPOSED APPLIED EXERCISES FOR BALANCING WATER SUPPLY AND DEMAND-[1]

The objective of this exercise is to apply the above-discussed methodology to the West Bank as a case study. The objective of the water balance model is to develop a comprehensive planning framework to achieve a sustainable water supply for the Palestinian communities in the West Bank for meeting water demands for the year 2020. Numerous water resources management and supply options have been proposed for the study area over the past few decades (Some of them are listed in Table 3). Some options involve technologies and planning tools, which are not presently known to be feasible. Attempts are made in this exercise to consider and discuss a wide range of views and options, but greater emphasis should be placed on technologies and tools that are flexible, implementable and widely accepted.

To facilitate the development of a realistic and goal oriented management framework for the West Bank, a focus group is proposed, it is comprised of 10-20 individuals who are involved in various aspects of water resources development, planning, management, research, and utilization in the West Bank. Accordingly, it

[1] Note: All numbers in this exercise are for demonstration purposes only.

can include representatives of Palestinian water institutions, universities, and research institutions, non-governmental organizations, and municipalities. The focus group may involve professional hydrogeologists, environmental engineers, economists, a systems analyst, irrigation engineers, water resources engineers, and lawyers. The main activities of the group are to review the proposed methodology and criteria for screening and evaluating options of water resources development.

The projected water demand for 2020 and an assessment of the available water resources should be estimated. Based on previous studies, the overall water budgets for the West Bank will show a shortage of water. Action on a number of fronts will be required to meet this challenge. Accordingly, many proposed options for matching supply and demand and improving water supply in the region in general and in the West Bank in particular should be analyzed based on Table 4. Table 6 shows a possible list of options.

The analysis of the possible options should be based on what is available in the literature and kept as brief as possible to provide a quick, readable resume of the options. The focus group should evaluate, screen options and assign weights to each of the planning criteria listed in Table 7.

Based on the methodology presented in the module, the options presented in Table 6 were screened and rated using the criteria and weights presented in Table 7. These ratings were summed to obtain overall scores for each of the options. Options with higher scores are ranked higher, and considered more compatible with the planning criteria than those with lower scores. The results of this screening are presented in Table 8.

TABLE 6 POSSIBLE LISTS OF OPTIONS FOR MEETING SUPPLY AND DEMAND

	OPTIONS
1	Development of local groundwater sources
2	Supply system improvements- municipal sector
3	Water conservation –municipal sector
4	Supply System improvement— agriculture sector
5	Water conservation – Irrigated agriculture sector
6	Development of local surface water resources
7	Intensive watershed management
8	Water pricing
9	Intersectoral reallocation
10	Wastewater reuse
11	Desalination of brackish water
12	Desalination of sea water
13	Medusa bags
14	Cloud seeding
15	Peace canal
16	Mediterranean Sea-Dead Sea desalination
17	Red Sea-Dead Sea desalination
18	Peace pipeline

BOX 2: OPTION NO. 1, DEVELOPMENT OF LOCAL GROUNDWATER SOURCES

- **CONCEPT:** The total potential renewable groundwater resource in the West Bank is 601Mcm/yr and 78 MCM/yr of brackish water for further development.
- **TECHNOLOGY/IMPLEMENTATION**: The technology for groundwater extraction is readily available.
- **COSTS:** The unit production cost of local groundwater in the West Bank ranges between \$ 0.25 and \$0.30/m^3. Financing, distribution, and treatment would increase these costs.
- **SOURCE WATER**: From the point of view of hydrologic uncertainty, the availability of the resource is reasonably well known and dependable. Production can be sustained up to the total renewable capacities of the aquifers.
- **POLITICAL**: The Palestinian share of the groundwater resources in the West Bank in not yet defined. Therefore, the extent to which the Palestinians may develop these resources in the future is a function of the Final Status Negotiations. Utilization of groundwater resources would provide Palestinians with a high degree of independence in the control of their water resources.
- **INSTITUTIONAL:** Management institutions necessary for effective utilization of groundwater resources would not have any out-of-the ordinary or exceptional staffing, training, or manpower requirements.
- **ENVIRONMENTAL**: The development of conventional water sources must take into account the sustainability of these resources. Groundwater development must be performed so that safe yield of aquifers in not exceeded.
- **SOCIAL:** Public acceptance of the use of additional groundwater supplies would be limited only by the price charged to water users.

TABLE 7. POSSIBLE PLANNING CRITERIA AND WEIGHTS

Criteria		Weights		
		Mean	Median	Range
Financial and economic viability		20	20	10 - 25
	Fundability	50	35	20 – 60
	Cost per unit of water	27	25	15 - 40
	Affordability	23	20	10 - 30
Technical viability		13.3	10	10 - 20
	Availability of technology	29.4	30	10 – 40
	Implementability	27.2	30	10 – 35
	Feasibility	24.5	30	15 – 40
	Flexibility and reliability of technology	18.9	20	15 – 30
Source viability		22.4	20	15 – 50
	Availability and hydrologic certainty	41.6	35	25 – 50
	Sustainability of quantity and quality	35	30	20 – 40
	Flexibility of supply development	23.4	20	10 – 35
Political viability		21	10	10 – 30
	Willingness of participant countries	29	40	15 - 50
	Political certainty of source country	30	40	20 - 60
	Compatibility with international laws	41	50	35 - 60
Institutional viability		7.1	5	4 - 12
	Availability and capacity of institutions	55.5	50	50 - 70
	Reliability of institutions	44.5	50	30 - 50
Environmental viability		8.8	7	4 - 20
	Impacts on the built environment	47.9	50	40 - 50
	Impacts on the physical and natural environment	52.1	50	50 - 60
Social viability		7.4	6	3 - 10
	Public acceptance	42.2	40	20 - 60
	Fulfillment of development needs	57.8	60	40 - 90

TABLE 8. RANK ORDER OF OPTIONS

Option	Score	Rank
Development of local groundwater sources	8687	1
Supply system improvements- municipal sector	8198	2
Water conservation –municipal sector	8139	3
Supply System improvement-– agriculture sector	8023	4
Water conservation – Irrigated agriculture sector	7900	5
Development of local surface water resources	7760	6
Intensive watershed management	7563	7
Water pricing	7321	8
Intersectoral reallocation	7218	9
Wastewater reuse	6900	10
Desalination of brackish water	6312	11
Desalination of sea water	5911	12
Medusa bags	5423	13
Cloud seeding	4908	14
Peace canal	4720	15
Mediterranean Sea-Dead Sea desalination	4708	16
Red Sea-Dead Sea desalination	4355	17
Peace pipeline	4223	18

Table 8 displays the 18 options in rank order, from most favored to least favored. Options that are obviously favored are those that rely upon development of local resources and improvements in the efficiency of the water delivery infrastructure and demand management (e.g., development of local groundwater, improvement of water supply systems and demand managements elements). These are generally followed by options that are more costly and that will require more time to implement (e.g., wastewater reuse, brackish and sea water desalination, and institutional modifications to support such approaches as water pricing). Finally, options that are ranked lowest are those that generally require large-scale imports and regional and international co-operation in the movement of water from one country to another.

Options presented in Table 8 describe possible water supplies which can be viewed as building blocks of different scenarios in accordance with its ranking. Scenarios consider taking some water from a selection of the options. The most favored can be combined or assembled in different ways to form individual and distinct scenarios for the development and management of water resources.

The extent to which each option could contribute to closing the supply/demand gap varies. It is difficult to assess the effectiveness of each option individually. Desalination, for example, could provide any amount of water, but at considerable cost. Cloud seeding on the other hand may make negligible contribution to supply augmentation and the success of cloud seeding is unpredictable. Each option should be considered individually to assess the quantity of water available or saved. Such an assessment is beyond the scope of this exercise and wculd be carried out as part of the full feasibility study.

This exercise shows how strategic and feasibility studies preceding any final decisions should include quantification of benefits of the potential results of demand management. A set of possible scenarios that offers realistic, plans to achieve sustainable long-term water supply should be analyzed. In real life situation, water professionals and policy makers should evaluate each scenario. This could be done by a steering Committee, which will assess the consistency or compatibility with planning criteria presented in Table 7.

H. REFERENCES

- CDM (1997) *Comprehensive Planning Framework for Palestinian Water Resources Development: Task 4*. Rammallah
- Duckstein, L., Gershon, M., and McAniff, R. (1982) Model Selection in Multiobjective Decision-Making for River Basin Planning. *Advances in Water Resources* 5(3):178-184.
- El-Ashry, M. (1991) Polices for Water Resources Management in Semiarid Regions. *Water Resources Development* 7(4):230-234
- ESCWA (1992). Water resources database in the ESCWA region. (E/ESCWA/ENR/1992/6)
- ESCWA (1994). Land and water policies in the Arab region". Contribution to the Expert Group Consultations on Sustainable Agricultural and Rural Development (SARD), held in Cairo from 25 to 29 September 1994.
- ESCWA (1995) Survey of Economic and Social Developments in the ESCWA Region 1995. (E/ESCWA/ED/1996/3/Rev.1) (United Nations publication, Sales No. E.96.II.L.18)
- ESCWA (1996) Water Resources Assessment in the ESCWA Region Using Remote Sensing and GIS Techniques: Final Report. (E/ESCWA/ENR/1996/7)
- ESCWA (1997a) Statistical Abstract of the ESCWA Region, seventeenth issue. (E/ESCWA/STAT/1997/8) (United Nations publication, Sales No. 97.II.L.10)
- ESCWA (1997b) Water legislation in selected ESCWA member countries. Paper presented at the Expert Group Meeting on Water Legislation in the ESCWA Region, held in Amman from 24 to 26 November 1996. (E/ESCWA/ENR/1997/2)
- ESCWA (1999) *Current Water Polices and Practices in Selected ESCWA Members Countries*
- ESCWA (1999) *Updating the Assessment of Water Resources in ESCWA Members countries*
- Gershon, M. and Duckstein, L. (1984) A Procedure for Selection of a Multiobjective Technique with Application to Water and Mineral Resources. *Applied Mathematics and Computation* 14:245-271.
- GWP (2001) *Integrated Water Resources Management,* TAC Background Papers, No. 4
- Hiple, K. (1992) Multiple Objectives Decision-Making in Water Resources. *Water Resources Bulletin, AWRA* 28(1): 3-12
- Le Moigne, G., Subramanian, A., Xie, M., and Giltner, S. (1994) *A Guide to the Formulation of Water Resources Strategy.* World Bank Technical Paper No. 263. Washington, D.C: The World Bank
- OECD (1985) *Management of Water Projects: Decision-Making and Investment Appraisal.* New Delhi
- Tecle, A. (1988) *Choice of Multicriterion Decision-Making Techniques for Watershed Management.* Unpublished Ph.D. Dissertation, School of Renewable Natural Resources, University of Arizona, Arizona